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ABSTRACT

This course entitled "Area Fish and Game Ecology" is one of a series of instructional guides prepared by teacher, or the Sahuarita High School (Arizona) Career Curriculum Project. I. consists of nine units of study, and 18 behavioral objectives relating to these units are stated. The topics covered include map projections, map symbols and contours, latitude and longitudinal, scale, using the contour line, plant life in the Sonoran Desert, mammals of the desert, birds, and fish. The units provide a statement of the rationale, objectives, and student activities. For related units in this series see SE 016 635 - SE 016 644. (JR)

SAHUARITA HIGH SCHOOL

CAREER

CURRICULUM

PROJECT

COURSE TITLE: AREA FISH AND GAME ECOLOGY

INTRODUCTION

BY

ROBERT ESSER

Objectives

1. Be able to tell the difference between parallels and meridions on a map.

2. Describe the three basic projections: 1 Cylindrical, 2 Conical, and 3 Asimuthal in map projections.

3. Describe contours and their purpose on a topographic map.

4. Describe symbols and how they are used in map reading.

5. Describe the difference between Latitude and Longitude.

6. Be sure to find the scale on the map and use the ratio used.

7. Given two points on a map be able to find ists distance with 95% accracy.

8. On a map you will be able fo find and explain how these are placed: Stream, hill, valley, lake, depression.

9. Explain all the infemmation on the margins of the map.

10. Make a plant press notebook with the common plants from three areas.

11. Name the plants you have collected.

12. Name the parts of plants you have collected and tell what their function is.

13. Pick an area that you can go to and observe the wildlife in it.

14. Be able to see the habitat of at least 14 of the given mammals.

15. Be able to name the external and internal antatomy of a bird when asked to do so.

16. Using the book a Field Guide to Western Birds by Roger Tony Peterson, identify 10 birds in the Santa Cruz Valley.

17. Write the natural histories of birds listed in activities.

18. Be able to use the Key to Fish with the Glossary of terms given.

BIOLOGY VII

Area Fish and Game Ecology
Introduction

We will begin our study with an introduction to topographic maps. By studying how we make maps and how they may be projected. Going on to map symbols and contours. Studying the vegitation and animals that inhabit the areas.

We will have films and guest speakers from the Arizona Fish and Wildlife Dept. and Federal Forestry Dept. They will discuss what they are doing and the careers available in these areas.

Aside from fieldtrips and classroom study, a student will be expected to do some study in the outdoors, in his own neighborhood.

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COURSE TITLE: AREA FISH AND GAME ECOLOGY

UNIT I

BY

ROBERT ESSER

Unit 1
A.F.G.& E.

Map Projections

Raticnal: We will ilustrate three types of projections-Cylindrical, Conical and Asimuthal form which most map projections are developed. These are just line vertical and horizontal in some respects on which a map may be drawn. The transparency we will use in lecture will show how this is done.

Objectives & Activities

1. Be able to tell the difference between parallels and meridions on a map.

1.1 Lecture and Deminstration on parallels and meridions.

1.2 Using local topographic maps find the parallels and meridions.

Objective 2
Describe the three basic projections: 1 Cylindrical, 2 Conical and 3 Asimuthal in map projections.

2.1 Demonstration and transparency project of the three types of projections.

2.2 Write the main reason for using these types of projections and the areas each are used in.

Evaluation.
Show instrutor that you know and have completed the objectives and activities.

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COURSE TITLE: AREA FISH AND GAME ECOLOGY

UNIT II: MAP SYMBOLS & CONTOURS

BY

ROBERT ESSER

UNIT 2 A.F.G.E

Map Symbols & Contours

Rational:

This is a short unit as was Unit I. Actually the first few units will be short but on material you must know and use. Unit 5 will be somewhat longer but is also part of the fundamentals needed in order for you to do your work. Try not to miss any classes in school for you will find it difficult to make up in order to understand what is happening in class when you return.

In this unit we will show an upper drawing of the land and then show a map adding the symbols and contours showing how they are used.

Objective I.

Describe contours and their purpose on a topographic map.

Objective 2.

Describe symbols and how they are used in map reading.

Activities:

I. Match transparency on symbols and contours taking notes that explain their use. (Symbols to know are water tank, railroad, church, building, mine, lakes, pier, airport, and well.)

2. Draw a simple contour map illustrating a stream flowing between two hills.

Evaluation: Explain the activity 2 to your instructor.

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UNIT III

BY

ROBERT ESSER

UNIT 3

A, F, G & E

LATITUDE AND LONGITUDE

Rational:

Imaginary lines which are drown on the tapo-graphic maps are called latitude and longitude. The parallels which go around the earth at the equator or up are called latitude. The Maridions which are drown through the poles crossing the other lines are called longitude. The O points here is the line going through Greenwich, England.

This crossing of lines make a grid from which amy point may be found. Also remember man made these lines to do just that.

Objective I.

Describe the difference between Latitude and Longitude.

Activity I.I

Watch & take notes on Transperency Lecture.

Activity I.2

Using top graphic maps in room show them to your instructor.

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UNIT IV

BY

ROBERT ESSER

UNIT 4

A, F, G & E

SCALE AND CONTOUR LINE

Rational:

Map Scale is the metro of the length of the map to the actual length on the land. This is usually located on the bottom center of the map.

The Contour Line connects all points that have the same elevation. Try one line if it can be followed would it join itself again and be a closed line. The Contour Line interval is the vertical difference (usually in feet) either rise or fall. There are certain Contour Lines that will have the elevation on them and with little practice you will be able to tell if you are going up or down on them.

Objective I:

Be sure to find the scale on the map and use the radio used.

Objective 2:

Given two points on a map be able to find its distance with 95% accuracy.

Activity I.I

Obtain a map and find the scale and explain it to a fellow student.

Activity 2.I

Have the instructor give you the information on the two points to find the distance between them. Have the instructor check your work or answer.

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COURSE TITLE: AREA FISH AND GAME ECOLOGY

UNIT V

BY

ROBERT ESSER

UNIT 5 A, F, G, & E

USING THE COUNTOUR LINE

We will study the shape.: of the Countour line for streams, and valleys to tell which way they are going. You will learn how to make a profile using the contour line. leteing this with 100% accuracy will enable you to use a contour map line in the classroom we must be able to use these out in the field also, so we will have some field trips to do that.

OBJECTIVE

On a map you will be able to find and explain how these are placed.

Stream, Hill, Valley, Lake, Depression

Activity 1.1

On a map given you find and show to your instructor a Stream, Valley, Lake, Depression and Hill.

OBJECTIVE 2

Explain, all the information on the margins of the map.

Activity

Find and show the instructor the below information on the map

1. Year map was made
2. Scale
3. Contour interval
4. Magnetic North and true north
5. Declination
6. Name of ajoining maps
7. Minute series
8. Latitude and Longitude Lines
9. Section numbers

INFORMATION SOURCES

1. Use notes and folder describing topgraphic maps and symbols.
2. Using area maps find the highest point, lowest point and other places given to you by your instructor.
3. Lecture with over head projector on Profile, Depression, Hills, and Valleys.

STEP 1.

Project the desired transparency and select one or more of the following approaches:

A. Three standard scales are used to denot different map series. A map scale may be defined as the ratio between a map distance and the same distande measured along the ground. Transparency MR-10 uses a verbal scale of 1 inch equals 2 miles. To what map series does it belong and what is its representative fraction? Determing the map series and verbal scale of MR-11 with a 1:24,000 representative fraction. Transparency MR-12 uses 1:63,360 as its representative fraction. To what map series does it belong and what is its verbal scale? What part does the map scale play in poortraying the relief of the area? Note the relatdonship between contour interval and map scale. Small contour intervals represent flat terrainand larger intervals are used for mountainous areas. What happens to the details of relief on MR-11 when a 50' contour interval is used? Why would a scale of 1:24,000 be unappropriate for an area such as MR-10? Additional questions of this nature may be constructed by referring to a list of standard scales.

SUPPLEMENTARY, PROJECTS, CONCEPTS AND QUESTIONS

1. Transparency MR-10. Identify the inlet and outlet of the lake. What is the elevation of the water surface? In what direction does the ourlet and/or inlet flow?

2. Transparency MR-11. What is the elevation of the water table in the central depression? What would happen to the central depression if the water table rose to 710 feet? Would there be water in the larger depression if the water table rose to 710 feet? Note the drection of the North arrow. In what direction is the larger depressionn from the depression containing water? Why is there water in the central depression and no water in the larger depression? Discuss the permeability and possible lithology of the larger depression based on the above questions.

3. Transparency MR-12. What is the drection of stream flow below the junction of the smaller streams? Determine stream gradient below the junction point. Which of the two small streams has the steepest gradient? Determine the maximum depth of the depression. Drawwa closed contour line in the bottom of the depression. Determine its elevation.

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CURRICULUM

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COURSE TITLE: AREA FISH AND GAME ECOLOGY

UNIT VI

BY

ROBERT ESSER

UNIT 6

Plant Life in the Sonoran Desert

The Sonoran desert of Southern Arizona has the largest cactus native to the U. S., the sahuaro. The Colorado desert, although merely an extension of the the Sonoran desert, has low saline flats covered by stands of saltbush. Former beach lines are occupied by ocotillo, and the mouths of the canyons to the west and north shelter many groves of native palms, relics of the day when this was a tropical sea.

The Mojave desert lies partly in and partly above the Lower Sonoran Zone. It, too, has a low basin that lies below sea level--the great sink known as Death Valley. Through much of this desert only the most drought-resistant plants can live, for this is one of the most arid areas of the world. The average yearly rainfall in several portions of the Mojave is 3 inches or less. Although even the joshua tree cannot withstand these minimums of moisture, it does surprisingly well on very little more, and is to be found in great profusion over much of this desert.

The Upper Sonoran Zone forms a continuous border along the edges of the lower desert. It extends from 4,500 to 6,500 feet in elevation. It consists mainly of four types of terrain: wide, gently sloping valleys, level mesa tops, low desert mountains, and the steep slopes encircling the higher mountains. Incl[illegible] within its borders is one desert so called, the Great Basin desert which covers most of Nevada and Utah. Indicator plants are not as easily chosen as those of the lower desert. In west Texas, New Mexico, and Arizona the lower portions of this zone are grasslands, the upper portions being taken up with emory oaks and juniper. Through the central parts of New Mexico, Arizona, and Nevada, juniper and pinyon are typical of the zone, and further northinto the Great Basin area sagebrush occurs in almost solid stands.

These are but a few of the plant species that mark the life zones of the desert. As a rule they occur within certain altitudes with amazing fidelity, except in cases, for instance, where a life zone will ascend well up on the southern slope of a mountain range, but will be confined to the lower slopes on the northern and colder exposure. Local climatic conditions can also affect their occurrence to a marked degree. Under average conditions... can also affect their occurrence to a marked degree. Under average conditions they provide a reasonably accurate means of distingushing one zone from another.

UNIT 6 A, F, G, & E

Plants Life in the Sonoran Desert

In this unit we will go on a full day field trip. We will collect plants from the areas we visit giving elevation and location.

You will be expected to make a plant press notebook for your own use in studying plants also you will help in making a plant press for the school as part of a class project.

We will also check for browsing of plants by animals in the area and you will need to keep a notebook with date and observation made on your own in an area of your choice.

Objective I

Make a plant press notebook with the common plants from three areas.

Activity 1.1

Get a spiral bound notebook 8 1/2 x 11

a. get small cutting about as a sheet in your notebook.

b. place plant in notebook and secure with scotch tape.

c. close notebook and press it firmly.

d. skip 2 pages and place next plant in it the same way.

Continue doing this and with each specimen collected put the date-area collected and elevations from a topographic map.

Activity 1.2

Field trip to areas chosen by class.

Objective 2.

Name the plants you have collected.

Activity 2.1

Using plant keys available in school name the plants you have in your plant press notebook.

The ones you can't find bring to the instructor and get help.

Objective 3

Name the parts of plants you have collected and tell what their function is.

Activity 3.1

Read in any of the Biology text on plant parts and functions. Then compare with your plants.

Objective 4

Pick an area that you can go to and observe the wildlife in it. Also you will need to collect plants and press them. The materials will be given to you by the instructor.

Activity 4.1

Pick an area that you will be able to visit easily for you will need to spend a couple hrs there about six different times this quarter.

Activity 4.2

Collect plants for plant press using instruction and techniques learned in class. Return this collection to school and classify it.

Test

1. Name plants in your area.
2. Turn in plant press notebook.

The following material has been deleted: Chapter 5: Vascular Plants from Science Teaching Tests--The World of Living Things.

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UNIT VII

BY

ROBERT ESSER

Unit 7

Mammals of the desert

Some people think the desert is a dry forbidden place with very little life. As you should know by now this is not true for the deserts here have abundance of life forms; but if you see them or not is up to you. It all depends on where, when and how you look.

MAMMAL ECOLOGY

Because animals have ability to move about it might be assumed that they would range far and wide, but this is true of comparatively few species. As a general rule, those animals which subsist on plant fruits or hervage will remain in a vicinity where this food is plentiful, but carnivores range in proportion to their size. This rule, like most rules, is proven by the exceptions. Many of the exceptions occurring in the Southwest are due to the highly specialized habits of a few of the desert species. Because the smaller rodents remain near their permanent homes, their movements are limited to a large degree. Kangaroo rats, for instance, live their lives out within a comparatively small area. This, in turn, has its effects on those animals which prey upon them.

The kit fox, which depends largely on these rodents for food, will remain in a vicinity where they are plentiful, although perfectly capable of migrating for great distances, if it should so desire. Most of the predatory animals of medium size, among them the raccoons, coatis, and coyotes are less restricted. This is due to their omnivorous food havits, larger size, and lack of dependence on a permanent home. The large predators, such as wolves, mountain lions, and jaguars, which are tied to one locality only for a short period necessary to rear their young, will sometimes travel hundreds of miles in search of new hunting grounds.

Such specialized creatures as the armadillo and hog-nosed skunk are to be found only in those localities where they are able to find the insects and worms which make up the greater part of their diet. Other mammals may be associated with certain plants which are native only to certain areas, and so it goes, each mammal being bound by association with other animals, plants, and topographical barriers to spend the greater part or sometimes all of its life in on specific location or life zone.

Objective 1 to see the habitat of at least 14 of the mammals listed below.

1. Javelina- Pecari angelatus
2. Coues White tailed deer-Odocoileus virginionus couesi
3. Desert Mule Deer- Odocoileus hemionus crooki
4. Pronghorn (antelope-Antilocopra americana mexicana
5. Desert Bighorn sheep-Ovis conodensis mexicana
6. Mountain lion-Felis concolor
7. Bobcat-Lynx rufus baileyi
8. Coyote-Conis latrous'
9. Gray Fox-Urocyon cinereoargenteus
10. Kit fox-Vulpes maerotis
11. Raccoon-Procyn lator Mexicanus
12. Coati Maundi (Chula)-Masua norica
13. desert Cottontail-Sylvilagus audubonl
14. Black tailed Jackrabbit-Lepus Califórnicus
15. Antelope Jackrabbit-Lepus alleni

These next two are not really part of the desert but are found as game animals in Arizona.

16. Black bear-Ursus americanus
17. Elk. (Wapiti)-Cervus conodensis

Activity 1.1

Fish & game expert on mammal habitats as guest lectures.

Activity 1.2

Field trip to desert Museum

Activity 1.3

Type of food used by animals studied

Activity 1.4

In your own study area spend approx. 3 mornings from 1/2 hr. before sunrise till approx. 1 hr. after. Also in the afternoon spend 3 of them in your area from 1 hr. before sunset until you can not see any more. Keep notes of activity you have observed.

Activity 1.5

Field trip into local areas showing some specific habitats of mammals.

Activity 1.6

Field trip to observe careers in Arizona fish & game department.

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UNIT VIII

BY

ROBERT ESSER

UNIT 8

BIRDS

There are many different birds. We will study not only game birds, but also habits, and natural history of a few other native birds.

Now go to the last pages of the unit. Read article taken from the life nature series THE BIRDS Titled "From Archaeopteryx to Sparrow". This will give you an insight to the development of Birds from Prehistoric to present time.

OBJECTIVE 1

Be able to name the external and internal antatomy of a bird when asked to do so. This will be directly from actual bird.

Activity 1.1

Collect a black bird or an English sparrow and find the external and internal parts. During season a dove or quail may be used.

OBJECTIVE 2.1

Using the book a Field Guide to Western Birds by Roger Tony Peterson, identify 10 birds in the Santa Cruz Valley.

Activity 2.2

Be able to identify in the field or classroom 10 species of birds given to you to study from memory.

OBJECTIVE 3

Write the natural histores of birds listed in activites.

Activity 3.1

Write a brief natural history of the game birds listed.

1. Mourning Dove and White Winged Dove (Zenaidura)
2. Turkey (Melegris Gallop)
3. Mallard (Anas Platyrhynchos)
4. Teal Blue Wing (Anas Discors)
5. American Coot (Fulica Americana)
6. Mexican Duck (Anas Diazi)
7. Canada Goose (Branta Canadesis)
8. Snow and Blue Goose (Chen Hyperborea)
9. Cinnamon Teal (Anas cyanoptera)
10. Band tailed Pigeon (Columbia Fascata)

TEST

1. With a bird in the lab name the kinds of feathers it has.
2. With a disected bird name internal anatomy with 80% accuracy.
3. Name birds from study skins in class.
4. Tell the natural history of one bird of your choice to the instructor.

FROM ARCHAEOPTERYX TO SPARROW

What manner of creatures are birds? Certainly, of all the higher forms of life, the vertebrates, or backboned animals, they are the most beautiful, most melodious, most admored, most studied-and most defended. They far outnumber all other vertebrates except fishes and can be found virtually everywhere throughout the world, from the edges of the polar icecaps and the highest Himalayan and Andean slopes to the roughest seas, the darkest jungles, the most barren deserts and the most crowded cities. The center of the Antarctic continent is the only place on the world's surface where birds have not been found. Some even invade the fishes' environment to a depth of 100 feet or more, while others hide in caves so dark that they must employ a sort of built in sonar to find their way about.

Nearly a century ago T. H. Huxley called birds "glorified reptiles." This term may grate harshly on the ears of gentle souls who keep parakeets or feed cardinals at the window, but there is much to support Huxley's contention. Birds share many characteristics with reptiles-certain skeletal and muscular features, similar eggs, and "egg tooth" on the upper jaw at hatching time, to name just a few. But the unique feature that sets them apart from all other animals is that they have feathers. All birds have feathers, and no other creatures possess them.

Considering the fact that life on earth extends back into the spectrum of time for more than two billion years ago, birds are a latter-day creation. Paleontologists believe that they began to branch off from reptilian stock sometime about

150 million years ago, shortly after the first mamals.

The oldest known bird in the fossil record dates back to the late Jurassic period, about 140 million years ago, and although there must have been still earlier birds or subbirds, this one has a dramatic significance all its own. It was brought to light in a slate quarry at Langenaltheim, Bavaria, in 1861, and would have been classified as a reptile except for the unmistakable imprint of feathers. The discovery was a scientific bombshell. Only two years before, in 1859, Charles Darwon had published his then controversial work, the Orgin of Species- and here was beautifully imprinted proof of this new theory, a missing link from the past: evidence that birds had evolved from reptiles. The fossil was named Archaepteryx, meaning "ancient wing." In 1877 a second skeleton was discovered about 10 miles away and in 1956 a third was found.

Although not quite a bird in the modern mold, Archaeopteryx was certainly not a true reptile. Its head, however, was lizardlike, with toothed jaws, its slender tail with many movable vertebrae was skeletally like that of a reptile, and its wing bones terminated in three slender, unfused, clawed fingers. Still, it had feathers.

Archaeopteryx probably did not fly easily, if we rationalize from its appearance, we might assume that it ran over the ground on strong legs and clambered up rocks, shrubs and trees with the assistance of its clawed wing-fingers. Its rounded wings and long but rather wide tail suggest that it was a glider that launched itself only for short distances, like a flying squirrel. It is perfectly clear from studying its anatomy, that it could not have flown very well. We can easily imagine the predicament which let to the fossilization of the three individuals so long ago. They were probably forced into reluctant flight by some pursuing reptilian predator, only to flop down on the water and mud from which they could not rise.

To this day, Archaeopteryx lithographica, which was abou the size of a pheasant, remains the only known species representing the subclass archaeornithes, or "ancestral birds," and we can only guess at the type of reptile from which it descended. This may have been one of the thecodonts, the possessor of long hind limbs on which it ran semirect, using its long tail as a balance.

Concurrently, also during the Jurassic, another reptilian experiement in flight resulted in the pterodactyls, which flew on slender batlike wings of skin. Though these creatures developed certain birdlike features such as beaks and light, pneumatic bones, they were not destined to survive. The Cretaceous period, which started about 135 million years ago and ended rougly 63 million years ago, saw their proliferation and also their demise while witnessing the rise of the "true birds."

These were the neornithes, birds such as Hesperornis, a toothed fiver resembling a huge flightless loon four or five feet long, and Ichthyornis, a small ternlike sea bird. Their remains were discovered in the Cretaceous shles of Kansas. A cormorantlike bird also lived furing this period and primitive flamingo has been foung in Scandinavia, so it is obvious that water birds had already diverged widely in form and adaptation by this time.

The current era is often called the Age of Mammals, as distinct from the Age of Reptiles, which drew to close with the exit of the dinosaurs and pterosaurs. The early part of this era, the Paleocene and Eocene, 63 to 36 million years ago, was a time of great development which saw the ascendancy of birds over reptiles. Many of the modern orders of birds emerged- including an ancestral ostrich, and primitive pelicans, herons, ducks, birds of prey, fowl-like birds, shore birds, owls, creanes and others . As we advance further, through the Oligocene and Miocene,36 to 13 million years ago, we find many modern genera appearing, birds very similar to present-day forms. A modern bird watcher, stepping back into time about 20 million years to scan a Miocene lake with his binoculars, would sppt many familiar-looking individuals but none that he could match precisely with those of today. But there also existed certain other birds that were in blind alleys; for example the phororhacids, huge flightless birds with massive heads nearly as large as those of horses. These fearsome fowl left no modern descendants.

During the Pliocene, 13 to 2 million years ago, many species emerged that fly on the earth today-species that can claim atiquity far greater than that of man. This was the period when birds enjoyed their greatest variety. Pierce Brodkorb of the University of Florida estimates that about 11,600 species were living contemporaneously, a theird more than exist today.

The Pleistocene, lasting one or two million years, when man was slowly coming into his own, was a time of pressure and exterminatation. The world was playing hot and cold with living things, alternating between glaciation and benign interglacial periods. The great ice sheets eliminated many plants and the birds scattered accordingly.

Today the number of spicies of birds on earth is usually estimated to be about 8,580, give or take a few score and depending on which systematists you choose to accept. The total number of extenct species described from fossil evidence is in the neighborhood of 800-less than 10 per cent of living species.

Actually, any paleontologist will point out that this does not give even a remotely true picture of the number of species that have existed during the last 140 million years. Birds, with their fragile, hollow bones do not lend themselves as well to fossilization as mollusks w h hard shells or mammals and large reptiles with their relatively solid bones. The road from Archaeopteryx to modern birds is paved with genesis and extinction. Species have arisen, have had their day and have faded away or given rise to new forms better adapted to a changing world. Recently Brodkorb, drawing on his knowledge of fossil history, came up with a tentative, over-all figure of 1,634,000 species, past and present. The living birds made up scarecly more than one half of one per cucent of this total. The others have followed Archaeopteryx into the void.

The biologist often speaks of "adaptive radiation." This means, in the evolutionary sense, that the descendants of a single species of animal may adapt to a number of new environments or modes of life. By so doing, they "radiate," changing in form and structure away from the ancestral type to a number of divergent types.

Adaptive radiation was strikingly revealed to Darwin when his research vessel, Beagle, dropped anchor at the Galapagos Islands 600 miles off the coast of

Ecuador in 1835. Here he found a complex group of small, black, finchlike birds now known as the Geospizinae. They were similar enough to ge recognizable as a group that had presumably descended from a single source, perhaps some seed-eating ground finch carried by the wind to these remote islands. Perhaps a small flock made the dea passage together. Sutviving, these first wind-borne immigrants found no other small birds to offer competition. Environmental niches were empty, so eventually the colonists, prospering and increasing, adapted to various modes of existence. When Darwin made his historic visit he found that some Geopizinines were seedeaters, as their ancestors are presumed to have been, but that others fed on insects, still others on cactus and one form even filled the role of a woodpecker. Their bills varied from thin, warblerlike bills to very think beaks like those of grosbeaks. They had, in fact, evolved so as to exploit virtually every feeding opportunity the islands offered to small birds.

When we discuss Galapagos finches we are talking about relatively recent radiation. Consider the extraordinary radiation from Archaeopteryx to the bewildering array of modern birds.

Evolution is a fluid process which can be represented by a two-dimensional family tree, but more accurately it is three-dimensional, with many twigs and branches dying off while others, reaching out in all directions, continue to modify and grow. The 8,580 species of birds on earth today represent growing twog ends. They are sparate entities, populattions that for one reason or another normally do not or cannot intervreed with each other. They are reproductively isolated. This large galaxy of living species has been arranged by systematists into 27 living orders of birds and these in turn have been broken down into some 155 families.

No one ornithologist has ever seen all the world's species in life-or even all of the families, except possibly in zoos. In fact, few are familiar in life with every order. For it is indeed an amazing diversity that exists in the world's population of birds from the fragile hummingbird weighning less than a penny to the ponderous ostrich weighing more than 300 pounds.

Several of the lower orders of birds cannot fly-the ostriches, the reheas, cassowaries and emus, the kiwis, and the penguins. This gave rise to a theory that modern birds did not all come from a common ancestor, but represented two lines of descent-one that had long ago attained flight and one that is not yet off the ground. Those who held this view theorized that the ostriches and other ratities (flightless, running birds with no keel on the breastbone), as well as the penguins, never had been able to fly and were still evolving their wings. However, this view has now been written off and it is accepted that these flight-less birds did have flying ancestors but lost the use of their wings because flight was no longer useful to their mode of life. In fact, flight becomes impossible for creatures as ponderous as the ratities, birds large and heavy enough to fill the nich of grazing animals.

Although the ostrich, with his heavily muscled bare thighs, is the largest living bird, even larger species were seen by primitive nam not many centeries ago. These were the moas (Dinornis) of New Zealand) and the elephants bird (Aepyornis)

Of Madagascar. The largest of the moas, like a huge pinheaded ostrich, stood. 12 feet tall and is estimated to have weighed 520 pounds. Moa "graveyards" containing hundreds of skeletons have been found in New Zealand and certain of the smaller moas were still numerous a thousand years ago when in the south island into the 18th Century.

Less is known about the elephant birds, which some like to speculate were Marco Polo's rocs. They were even more heavily built than moas and may have weighned as much as half a ton. Whether man destroyed the last of the elephant birds and, if so, how recently, is not known. Early travelers to Madagascar described Aepyornis eggs which were used as flasks by natives. A few such flasks are still in existence and they hold two gallons of liquid.

The ostrich, the gieant among living birds, attains a stature of eight feet. It lives the life of a grazing animal, roaming in little parties over the African veldt in the company of zebras, wildebeests and gazelles. It has the distinction being the only bird with two toes, one much reduced in size, suggesting that this fleet-footed monster, which can run as fast as 35 miles per hour, is on its was to acquiring a one-toed foot like the horse.

The two rheas, often called the "South American ostriches" are superficially like their African counterpart, but they have three toes and feathered thighs, and lack the ostrich's handsome plumes. Nevertheless, as they race across the pampas, they give much the same effect as small ostriches.

Australia also has its ratities, or ostrichlike birds-the emus and the cassowaries. They, too, are without the ostrich's plumage, and they have even more rudimentary wings and a hairy, almost shaggy look. Australian farmers hold a perpetual grudge against the fast, 120-pound emu because it damages fences and raids crops. Less often seen are the related, forest-dwelling black cassowaries of northern Australia and New Guinea. Papuan natives have a cautious respect for these temperamental birds.which have been known to disembowel men with quick slashes from the long, daggerlike nails on their inner toes.

The strangest and perhaps most primitive of all the ratites are the kiwis of New Zealand. Certainly they are the most unbirdlike of all birds, shmoolike creatures shaped like large, hairy footballs and practically devoid of external wings. They have whiskery faces and nostrils placed at the very tips of their long beaks, the better to locate worms during their nocturanal forays. The kiwi's enormous five-inch egg weighs nearly a pung, one fourth to one third of the bird's body weight. Constrast theis with the six-to eight-inch ostrich egg. which weighs only one sixtieth as much as the female!

From Mexico southward throughout most of the South American continent live the tinamous-chunky, almost tailess birds that lay deeply colored eggs so glossy that they look like porcelain. These ground birds with the haunting, whistled cries look strikingly like partridges, but are mot even distantly related to them. Evolution often results in unrelated birds looking rather similar, especially when they fit a similar environment. a phenomenon call "convergence," the opposite of radiation. Tinamous are low in the family tree of living birds, supposedly close to the flightless ratites, but they still have the ability to fly.

The torpedo-shped loons and the smaller, lobe-footed grebes are both foot-propelled divers with feet placed far back toward the tail. At first glance they would seen to belong to the same order. Actually, they are quite unrelated, coming from different ancestral lines-another example of convergence.

Penguins cannot fly, yet they have a strongly keeled breastbone and powerful flight muscles. Here the wings have evolved into flippers, and penguins literally fly through the water, using their fleshy feet as rudders. Because their upright posture, waddling gait, dangling flippers, and frock coats all add up to a lovable caricature of Homo sapiens, penguins have always appealed to humans. All but one of the 15 living species are birds of the cold seas of the Southern Hemisphere.

Oddly enough, the flightless penguins may have evolved from the same ancestral stock as the albatrosses, the supreme masters of flight. Students point out that they have in common a beak made up of horny plates, quite unlike the simple sheathlike bills of most other birds. Eons of evolution have made one an avian submarine,,the other a sailplane.

Albatroses, petrels and shearwaters all belong to the order of "tube-nosed swimmers," so called because the nostrils, unlike those of most other birds, are in short tubes on the sides or on the top of the bill. They are the blue-water seaman's companions and range in size from the swallow-sized black-and-white storm petrels to the wandering albatross, whose wings span more than 11 feet. Although they roam all oceans, the majority of species live in the southern hemisphere and are especially numerous between the Antarctic ice pack and the southern tips of the continents.

The word albatross was an English corruption 66 alcatraz, the name the Portuguese seaman applied to all large sea birds, especially pelican. Pelicans, however, are not closely related to albatrosses; they belong to the next great order of birds, the "totipalmate swimmers, " which differ fromm all other footed birds by having the hind toe joined to the front three by a web. They also have throat pouches, relatively small in the boobies, cormorants, anhingas and frigat bird, but enormous in the pelicans- some of them have a pouch capacity of nearly three gallons. All birds of this order are fisheaters; most but not all are marine.

Modern birds, adapting and changing during the last 100 million years, have filled virtually every available niche in the world. About 120 living species of "long-legged waders" have evolved. These birds-the herons, storks, ibises and related birds with stiltlike legs for stalking the shallows and long compensating necks - make their living catching small fish, frogs and other forms of aquatic life. Bills take variety of shapes-datterlike or spearlike. upturned, downturned, shoelike and even spoonlike.

The most specialized of all the wading birds are the colorful flamingos. Students hotly debate whether they are more closely related to storks, which they superficially resemble, or to geese. Their gooselike cries, gooselike young, their molts and even their feather parasites sugges an affinity with geese. Certainly they have developed a way of life unique among birds, evolving grotesquely exaggerated necks and legs and think, bent bills eqpped with fringed lips for straining edible organisms from the souplike mud in which they wade.

The waterfowl, the familiar web-footed swimmers which form the sportsman's game, include the ducks, geese and swans, The distinctive feature that most of the 146 species have in common is a flattish "duck" bill, although the dabble, others dive for a living, while swans, with necks longer than their bodies, dip or tip up for their diet of aquatic plants. Geese, shorter-necked, also do this but primarily graze on and for grass and roots.

Among the most spectacular of all groups are the birds of pry. Superbly de-signed for their predatory task, they are powerful fliers, capable of effortless soaring or plunging bursts of speed. There are over 270 living species in this order. All have hooked beaks for tearing flesh, and those which take living prey charateristically have strongly hooked talons. Vultures, those naked-head-ed birds of prey which feed on carrion, have weaker feet- obvious adaptation, since their prey cannot escape. Owls, though nocturnal birds of prey,=are not included in this order; more will be said about them later.

The fowl-like birds, numvering about 250 living species, embrace the grouse, turkeys, quails, partridges, pheasants, currassows, guans, mound builders and the primitive hoatzin. They are sturdy ground birds, with grubbing bills and sto , acratching toes. Some are among the worl's most gorgeous birds, others notably the domestic fowl, are among the most economically important.

The cranes are storklike, whereas rails and coots are more like hens and hide in the reeds. The bustards are heavy-bodied walking birds of treeless plains. All birds of ancient lineage, they may be losing the fight for survival.

The shore birds, gulls and auks form another order, also united because of internal anatomical similarities. The birds of this multifarious assemblage numbering nearly 300 species are highly gregarious and are tobe found more widely throughout the world than any other group. The shore birds are small to midium-sized waders that flock along the margins of waterways and the ocean. The gulls and terns are graceful aerialists. Auks fit the same niche in northern seas that penguins do in the southern Hemisphere, but have not lost their power of flight. Indeed, they have double-purpose wings which enable them to fly through the air and under the water as well.

Four fifths of the world's living birds are made up of the various orders of land birds, which seem to have had their greatest development in recent geoplogical time. The worldwide pigeons, for example, and the Old World sandgrouse, with their small-headed, short-legged look, total more than 300 living species. They are the only birds able to suck up water when drinking; all other species have to tip their heads up to let the water flow down their throats.

The gaudy parrots, which come in all the colors of the rainbow, are big-headed with deep, hooked beaks and dexterous, prehensile feet. Living for the most part throughout the tropics, they number 317 living species. Bot far removed from them anatomically but quite different in shape are the worldwide cuckoos and the touracos of Africa, slim-codied birds with lond tails. Their feet, with two toes forward and two aft, as in the parrots, are weaker and lacking in dexterity. If we lump the cuckoos and touracos the order numbers 143 species.

Owls were once classified with the hawks because of their hooked beaks and curved talons, but they are actually unrelated to those predatory birds. Rather they furnish another good example of convergent evolution, birds of separate orgin. Developing similar features because of their way of life. Owls take over the night shift from the day-flying hawks and are best characterized by their loose feathering, large heads and large forward-facing eyes framed by round facial disks. Nearly worldwide, they number 132 species.

Another order of nocturnal birds, the goatsuckers, possess fluffy owl-like plumage, but their beaks and feet have degenerated into insignificance. They are flying insect traps, capturing their quarry in cavernous gaping mouths. The whippoorwill and the nighthawk are the best-known North American examples of this group, which numbers 92 species.

The most aerial of birds are the swifts, saber-winged, swallowlike birds that spend all their active hours in the open sky. As in the goatsuckers, beaks and feet have atrophed to near uselessness. Most systematists lump the swifts in the same order as the hummingbirds, pointing out that they branched off the same stem. The gemlike, needle-billed hummers, which include the tinest of all birds, number perhaps 320 species and are all found in the New World. No Old World group has ever become as efficient at the delicate art of nectar feeding.

The layman is puzzled when he reviews the orders of birds. Why are ostriches, rheas and emus put into separate orders when they look so much alike? On the other hand, birds as dissimilar as sandpipers and puffins are palced in the same order. So are cranes and coots. All of this becomes even more puzzling when one looks at the orders of land birds.

Systematists find that the superficial appearance of birds may be deceiving. Unrelated birds may look similar because of a similar way of life-evolution has decrees it so, and they have converged. On the other hand, birds may look very different yet have come from the same ancestral stock; they have diverged. For this reason students are more likely to base their decisions as to the major groups on such points of internal anatomy of the foot-characteristics that indicate more accurately their common ancestry.

Thus the colies, or mousebirds, a small group of six African birds with crests and slender tails, have been put in an order of their own, based partly on their curious foot structure. So have the brightly colored tropical trogons, which are among the world's most beautiful birds.

The kingishers and their allies are another great order of fantasiic variety classified by their peculiar feet, which are syndactyl, having the front toes joined for part of their length. The kingfishers with their spearlike bills are nearly worldwode. Other qaudily colored familes belonging to this order are the tiny, chubby todes of the West Indies; the motmots of the American tropics that that handsome beeeater, the rollers and the hoopoes of the Old World; and the huge, bizarre hornbills of the Old World tropics. All 192 species nest in holes, usually in banks of earth or trees.

The woodpeckers and their allies, numbering 377 species, are also hole nesters and include such dissimilar failies as the barbets with their whishery bills, the iridescent jacamars and huge-billed toucans. The toucans make up for the lack of hornbills in the New World tropics.

Condensed as this brief review of this has been, it still gives an idea of the great variety of the order. None, howefer, can compar with the passerines, or perching birds, This order is by far the largest; it contains just about 5,110 species, which have been divided into about 55 familes. They range in size and bewuty from tiny wrens to large, gorgeous birds of paradise and lyrebirds. This galaxy, three fifths of all the world's birds, has developed most strongly in relatively recent times. In an epoch when such ancient typed as theostriches, pelicans, cranes and others are on the way out, the passerines may well inherit the earth, or that fragment of it that man spares for them.

Although many systematists today regard the finches and sparrows as the most "evolved" of all the perching birds, the older ornithologists put the crows and jays at the top of the family tree. Perhpas they were right; certainly these resourceful birds are plastic, relatively unspecialized, opportunistic and probably capable of much further evolution-and that is what counts.

SAHUARITA HIGH SCHOOL

CAREER

CURRICULUM

PROJECT

COURSE TITLE: AREA FISH AND GAME ECOLOGY

UNIT IX

BY

ROBERT ESSER

UNIT 9

FISH AND OTHERS

Though we live in the desert, there is plenty of op[illegible] to enjoy water sports in Arizona. This may [illegible] Lake, a tank or a larger lake like Rosevelt. So we will study some of our more aquatic animal friends.

We will also look at some of the careers first hand that have to do with recreation around the water areas in the state and those that support it.

<u>Objective 1.</u> Be able to use the Key to Fish with the Glossary of Terms given.

<u>Activity 1.1</u> Use Glossary of Terms, find as many of them on representative fish in the classroom.

<u>Adipose fin.</u> A fleshy, rayless fin posterior to the dorsal fin.

<u>Anal fin.</u> A median, ventral fin located just behind the vent.

<u>Barbels.</u> Slender, fleshy projections on the head, located near the mouth.

<u>Branchiostegals.</u> Bony rays in the gill membrane.

<u>Buccal funnel.</u> A depressed area with the mouth in its center.

<u>Caudal peduncle.</u> The region between the anal and the caudal fins, the fleshy part of the tail.

<u>Caudal fin.</u> The tail fin.

<u>Cheek.</u> The area lying between the eye and the opercle.

<u>Circumoral.</u> Around the mouth.

<u>Ctenoid.</u> Scales with a pectinate or roughened posterior, exposed surface.

Cycloid. Scales with a smooth posterior margin, more or less circular in outline.

Deciduous. Temporary, characterized by falling off at a certain time.

Dorsal fin. The median umpaired fin on the back.

Fin rays. Soft bony structures which branch or diverge at their outer ends.

Fontanelle. An unossified space on the top of the skull, covered with a membrane.

Fusiform. Spindle-shaped, tapering at both ends.

Gill or Branchiostegal membrane. The membrane on the under side of the opercle.

Gill filaments. Rows of delicate, red filaments on the outer edge of the gill bar.

Gill rakers. A series of projections attached along the inner surface of a gill bar.

Imbricate. Overlapping like shingles on a roof.

Isthmus. The median fleshy area under the throat and between the gill clefts.

Keeled. Raised to a sharp ridge or edge.

Lateral line. A series of sensory structures appearing as a line running from the opercle to the tail fin on the sides of the body.

Lingual lamina. Horny plates bearing teeth-like spines on tongue of lampreys.

Mandibular sumphysis. Anterior point of union of the bones of the lower jaw.

Maxillaries. The posterior lateral bones of the upper jaw.

Multicuspid. With may sharp projections.

Nape. The dorsal region just behind the head.

Obtuse. Blunt, forming an angle greater than a right angle.

Opercle. The bony flap covering the gills.

Orbit. The eye socket.

Osseus. Bony.

Palatines. Bones supporting the roof of the mouth, back of the vomer

Pectoral fins. The anterior paired fins.

Pelvic fins. The posterior paired fins.

Pharyngeal teeth. Teeth found in the throat region on the inner margin of the gill bars.

Plicated. Folded or wrinkled.

Premaxillaries. The bones, one on either side, forming the front of the upper jaw. (Often extending back parallel to or superimposed over the maxillaries).

Preopercle. The front of the opecle bordering the cheek.

Protractile. Capable of being thrust forward.

Pseudobranchia. Small patch of gill filaments on inner surface of opercle.

Pterygoid bones. Bones located back of the palatines.

Pyloric caeca. Elongated, blind sacs opening into the intestine at juncton with the stomach.

Serrate. Netched like the teeth of a saw.

Snout. Region of the head extending ferward from the eye orbit to the tip.

Spiracles. Paired openings in the head just in front of the functional gills; remnants of the first gill cleft.

Standard length. Distance from the tip of the snout to the posterior margin of the hypural plate or to the last vertebra at the base of the tail fin.

Tesselated. MMarked with a checkered pattern.

Vent. Anus and excretory opening.

Ventral fin. Same as pelvic fin.

Villose. Covered with short, finger-like projections

Vomer. Anterior bone in the center of the roof of the mouth.

Activity 1.2 Read and study article on Some Facts About Fishes.

Activity - Field trips to Pina Blanca Lake. Collection and notes must be done for use in class.

SOME FACTS ABOUT FISHES

Fishes represent the largest division of the vertebrates. Many fossil fishes are known which were very primitive and are considered as the earliest vertebrates. From some of these the modern fishes have descended. Modern fishes, although containing a few relicts of these ancient groups, are mostly highly modernized forms as well adapted for their mode of life as land animals are for a terrestrial life. In fact, some fishes show more highly developed and more specialized structures than any of the other vertebrates. Flying forms have developed. In many groups luminescent structures and powerful electric organs have appeared.

The fishes living today can be divided into the cyclostomes or round mouth eels (Agnatha), the cartilaginous fishes (Chondrichthys), and the bony fishes (Osteichthys). The cyclostomes are found in both freshwater and the sea, and are offshoots of the earliest types of vertebrates known. While they are primitive in that they have never developed the teeth, upper and lower jaws, paired appendages or fins, the living cyclostomes are highly specialized for a semi-parastic life. The cartilaginous fishes also represent the modern descendants of an early group and today consist mainly of the sharks, skates, and rays. In the United States these are all marine and only a few occasionally wander into the mouths of rivers. These are not included in this book. The bony fishes constitute the greatest group of living fishes populating the freshwaters and seas of the world with all types including many highly diversified.

The bony fishes include a few primitive forms, the superorders Chondrostei and Holostei, which are relicts of the United States. Except for a few cyclostomes, all the other freshwater fishes of the United States are modern bony fishes of the superorder Teleostei.

Most of the fishes in our inland waters are restricted to freshwater and cannot live in the sea. Fishes which spend most of their lives in freshwater but go to the sea to spawn, are known as catadromous fishes. The only common catadromous fish in the United States is the American eel. Fishes which spawn in freshwater, but spend most of their lives in the sea, are known as anadromous fishes. Many fishes, such as, the Pacific salmon, some shad and smelt spend most of their lives in the sea, but regularly enter freshwater to spawn. These are considered as freshwater fishes in this book. Some freshwater fishes, such as the trout, have anadromous races which commonly go to sea, but return to freshwater for spawning.

Some freshwater families have species which often invade the brackish or sea water at the mouths of rivers, but never venture far into the sea. Some of the salt water fishes frequently invade the freshwater at the mouths of rivers and some may penetrate upstream for several hundred miles. In this book some of the marine fishes which commonly invade freshwater are included, but the number occasionally entering freshwater is so great that it would make the keys too cumbersome to include all marine fishes that have been reported from freshwater.

The freshwater fishes of the United States do not reach the enormous size attained by many of the marine fishes or by some of the freshwater fishes in other parts of the world. A weight of several hundred pounds may be reached by some catfishes and the lake sturgeon. The anadromous white sturgeon of the Pacific northwest has been reported weighing over 1000 pounds. Several of our freshwater fishes are quite minute seldom exceeding an inch in length such as gambusia, the pygmy sunfish, and the least killfish.

DISTRIBUTION AND CONDITIONS FOR EXISTENCE

The distribution of fishes is usually determined by stream systems as land divides often constitute an effective barrier. The greatest separation of American fishes is caused by the continental divide which rather effectively has separated the fishes of the Pacific drainage from those of the Atlantic drainage. In most cases entirely different species and even genra occur on the two sides of the divide. A few species have crossed apparently at the narrow divide between the headwaters of the Missouri and Columbia Rivers. The Arctic and the Great Lakes drainages have had many connections with the Mississippi drainage and, consequently, show many species common to both. Several fishes found in the Artic drainage have penetrated into the northern part of the Mississippi drainage, but are probably restricted from going farther south because of suitable living conditions. The Atlantic drainage shows that many fishes from the Mississippi drainage have been able to cross the divide, but there are many species which are restricted to the streams of the Atlantic seaboard. In some cases these are continuous in the coastal streams along the Gulf of Mexico.

There are many cases of isolated stream systems containing endemic species, such as, stream systems of the southwestern desert which have lost all connectons with other basins and empty into lakes without any outlets. Also coastal rivers, such as the Sacramento and many rivers in southeastern United States, are isolated and have developed partially endemic fish faunas:

Many fishes show individual preferences for certain water conditions and are to a certain extent restricted in their distribution by these conditions. Some fishes, such as members of the salmon family, are restricted to cold waters and will not be encountered in regions where there are no waters within optimum range of temperature. Other fishes prefer warmer waters, such as black basses and sunfishes, and thrive best in waters which reach temperatures above 75°. The various ciscoes, the Great Lakes whitefish, the lake trout, and a few other fishes are restricted to lake waters and avoid streams. Other fishes prefer running waters and are more likely to be found in rivers. Certain darters are found only in small swift streams. Fishes, such as the larger cotfishes, are more likely to be found in the larger and more placid rivers. Land barriers between stream systems are not the only condition limiting the range of a fish, as the proper habitat for that particular species must also be present.

Fishes depend on many other conditions for their existence, but fortunately many of these conditions, such as food, are ample in most freshwaters. If the salt content is too great, as in Great Salt Lake, it will prevent any fish from living there, but in most waters the salt content is within the tolerance for most fishes. The carbonate or lime concentration, although important to the growth of food organisms, is usually within the tolerance of fishes. Proper spawning beds are a very important factor and often form a limiting factor as most fishes need certain depths, bottom types and wate. temperatures for spawning, and without these conditions they cannot maintain the species.

A necessary factor in the existence of fishes is the presence of sufficient oxygen for respiration. Fishes obtain their oxygen from that dissolved in the water and cannot live when this falls below a certain concentration. Some shallow waters in the north may develop an insufficient amount of oxygen during the winter. Much of the oxygen in standing water originates from the oxygen given off by aquatic plants during photosynthesis. When sunlight is cut off by snow on the ice, the photosynthesis stops, and the shallow lakes may lose most or all of their dissolved oxygen. Streams obtain most of their oxygen from the atmosphere as the flowing water rolls along and rubs against the air. Consequently, streams usually do not show as much winter oxygen reduction. An important contributing factor to oxygen reduction is the decomposition of organic matter. An abundance of organic matter, such as a heavy weed crop or even domestic sewage through the oxidation processes of decomposition causes a great oxygen consumption and often results in depletion of the oxygen. This is one of the chief reasons why pollution renders water unfit for fishes.

In many of the deep northern lakes, the cold water stratifies in summer and remaisn below the warmer surface water and is too deep for photosynthetic activity. If considerable organic matter has settled into this deep water, oxidation may soon deplete the oxygen from the lower levels and cause the fishes to be confined to the upper levels. Only those deep lakes which are not fertile enough to produce much plant life have sufficient oxygen to maintain fishes in their lower levels. Large lakes with strong currents may keep the water sufficiently stirred to prevent any stagnation.

ACTIVITIES

Most fishes feed on or close to the bottom and hence are restricted to water where they can always reach the bottom. A few fishes are pelagic and live in the deep open waters of large lakes. These feed chiefly on plankton or other fishes which are in turn plankton feeders. Fishes exhibit all sorts of feeding habits. Young fishes when first hatched usually start feeding on the minute crustacea which swarm in the shallow water. Many soon turn to small insects and fry of other fishes. Many of the minnows, bullheads, and other rough fishes consume large quantities of plant food. A few fishes are plankton feeders, possessing fine gill rakers by which they strain out the tiny crustacea and other planktonic forms which swarm through the open waters of all lakes. The game fishes are mostly predaceous, feeding on smaller fishes and on all sorts of other aquatic animal life. Thus long chains of food habits are established. The forage fishes feeding on plants and on plankton, furnish food for the predaceous fishes which top the chain. Suckers sweep over the bottom with their sucker mouths utilizind anything that is edible. In between are the insectivorous fishes, such as crappies, sunfishes, and perch, feeding mainly on the smaller animal life, but occasionally feeding on small fishes and in turn sometimes eaten by the larger game fishes.

Fishes exhibit definite working hours as do most animals. Some are diurnal and start their activities after sunup. Others are nocturnal and are most active at night. Night feeders usually have seen sense of taste and smell by which they partly or wholly locate their food. Diurnal fishes usually locate their food by taste and sight and some, such as the pike, use sight almost entirely.

Many fishes are gregarious and tend to keep together in "schools." Others, such as the adult pike and blach basses for the first six months of their lives are gregarious, but they soon separate and each male more or less selects his own territory which he defends against all invaders. The relates sunfishes remain gregarious, and even when spawning are so sociable that they may put their nests as close together as possible. Bullheads are gregarious and swarn in schools.

Fishes exhibit several types of definite movements. The spawning runs of many are well known. The suckers and the walleyes follow definite paths to their spawning beds at the start of each spring. The mad crowding rush of the Pacific salmon, smelt, shad, and many other anadromous fishes to their spawning beds are well known classic examples. Less spectacular are the spawning runs of many of our freshwater fishes, such as those of the suckers.'

We are just beginning to learn about the daily movements of many of our common fishes. Pike move ~~into~~ the shadow waters outside of the weed beds to spend the night. On the other hand, the pike-perch move inshore at sundown and spend the night in shallow water [illegible] side the weed beds during the early morning to spend [illegible] and sunfishes also exhibit similar daily movements. Each kind of fish seems to have worked out a definite pattern of activity which may vary with the age of the fish.

REPRODUCTION

Fishes are usually very prolific breeders, producing enormous numbers of eggs which compensate for the numerous hazzards to which the eggs and young are exposed. The number of eggs produced per fish may vary from 15 to 20 as in some live-bearers to over a million as in the carp and eel. Most fishes produce eggs which are fertilized and hatched after they are laid. A few, such as the members of the family Poeciliidae, are live-bearers, giving birth to the living young. In this case the eggs are retained in the oviduct where they are fertilized by sperm introduced by male. The eggs develop and actually hatch within the mother who thus gives birth to living young. In these fishes the number of eggs are few. but the chance of survival is great.

The majority of our freshwater fishes are egg-laying and have developed two methods for developing the eggs. One method, and perhaps the most common, is that of depositing the eggs at random on suitable but unprepared spawning beds. The eggs are fertilized as they are laid by one or more attending males and are left to develop and hatch without any further care. These random spawners produce enormous numbers of eggs, often many thousands or more. A number of our fishes, such as sunfishes and catfishes, are nest builders and prepare a nest, usually a cleared depression where the female deposits the eggs which are then guarded by the male who also guards the young fry for some time afterwards. These fishes usually produce only a few thousand eggs, and the change for survival is much greater than in the random spawners. There are a number of fishes that have even guarding the eggs but giving no care to the young. Many minnows prepare nests and some even guard eggs. Many trout make some preparation covering their eggs with gravel and then leaving the eggs to shift for themselves.

STRUCTURE OF A FISH*

In order to identify a fish it is necessary to know something about the structure of a fish especially those parts used in classification. The shape of fishes vary greatly. Many have slender streamlined bodies, but others develop thick heavy bodies, fitting almost every conceivable dimension. Some may be very long and cylindrical as in the eel, others are compressed laterally and are deep vertically as in the sunfishes. Proportions vary greatly. Some fishes have large wide heads and small slender bodies, while others may have small heads with wide heavy bodies.

The general terms of anatomical dimensions apply to fishes the same as to other animals. Anterior refers to before or to the front end or part of the body or structure. Posterior refers to behind or to the hind end or part of the body or structure. Dorsal refers to the back or upper surface. Ventral refers to the under part or lower surface. Lateral means the sides or toward the sides. Medial refers to the central part or middle of the body or structure.

The body of a fish is divided into three regions, consisting of head, trunk, and caudal regions (Fig. 1). No neck is present, although the region of the back just behind the head is called the nape. The head is that part extending to the posterior edge of the [illegible] cover or opercle. The trunk is the region from the edge of the opercle to the anus. Several areas may be found in the trunk. [illegible] The pectoral (shoulder) area is just behind the opercle and includes the humeral area which is the area just above the base of the pectoral fin. The abdomen or belly is the extreme ventral portion between the pectoral fins and the anus. The thorax or breast is the ventral area immediately in front of the pectoral fin.

The tail or caudal region (Fig. 1) is the region from behind the anus extending to the caudal fin, and is not the caudal or tail fin. The more or less slender part of the caudal region behind the anal or dorsal fin (whichever extends farthest back) and extending to the base of the caudal fin is the caudal peduncle. The anus (Fig. 2) is the posterior opening of the digestive tract and is adjacent to the openings of the urogenital tracts. The general area of the anus is often swollen.

Fishes possess several kinds of fins, which are usually membranous structures supported by rays or spines. Rays are modified into soft and hard rays. Soft rays (Fig. 1) are slender flexible structures composed of many bony joints and are typically split or divided at their outer ends. The soft rays at the front of a fin are usually short and are not divided at their tips and are known as rudimentary soft rays (Fig. 2). When counts of the fin rays [illegible], the short rudimentary rays are not included but the long unbranched ray usually found at the front of the dorsal and anal fins is usually included in the count. The last [illegible] ray of both dorsal and anal fins is often split [illegible] to the base and [illegible] for two rays.

[illegible], such as the [illegible] the European carp, [illegible] soft rays [illegible] like structure known as hard rays. These [illegible] at their membranous [illegible] their jointed structure will be detected. True spines (Fig. 2) are stiff rays ending in sharp points and do not show a jointed structure.

The median or un-paired fins of a fish consist of the dorsal, caudal and anal fins. The dorsal fin (Fig. 4) extends along the middle of the back and may be divided into several parts, the anterior portion often being spiny. The tail terminates in the caudal fin which has developed several types. Primitive fishes or relicts of ancient groups have a heterocercal type (Fig. 3) in which the vertebral column extends out into the upper lobe of the fin. A modification of this type (See Fig. 14) occurs in the Families Amiidae and Lepisosteidae, where the young are hatched with typical heterocercal fins, but lose the upper lobe as they grow. Most fishes have a homocercal type (Fig. 4) of caudal fin where the vertebral column ends at the base of the fin. This type may be forked, rounded or square. The caudal fin is composed of soft rays with rudimentary rays on each side. The term fulcrum (Fig. 2) applies to the swollen area above and below the base of the caudal fin produced by the continuarion of the rudimentary rays.

The anal fin (Fig. 2) is a median ventral fin located just [illegible] the anus. It may be composed [illegible] both spines and soft rays. The shape of the anal and dorsal fins is usually not highly [illegible] but sometimes one or both of these fins may [illegible] a [illegible] sickle-shaped form (Fig. 5) with an "S" [illegible] edge.

Corresponding to arms [illegible] most fishes, [illegible] one or both pairs are [illegible] fishes. The anterior [illegible] are the [illegible] not too laterally on the shoulder girdle just back of the [illegible] The pelvic fins (Fig. [illegible]) are typically located just anterior to the anus, but in many fishes they move forward. When the pelvic fins are near the [illegible] they are termed abdominal in position (See Fig. 21), but when they are near or under the pectorals they are termed [illegible] in position (see Fig. 22). In some species they may [illegible] anterior to the pectoral fins and are termed jugular in position. In many fishes slender ridges or structures known as axillary processes (Fig. 2) are found in the angles at the base of the pelvic fins.

Another type of fin found in some fishes is the adipose fin (Fig. 2) characteristic of trout, catfishes and several other groups. This is a small median fin behind the dorsal fin distinguished by being a soft fleshy structure without any rays or spines.

The body of a fish is ordinarily more or less covered with scales. Sometimes the scales are so small they can barely be detected. Areas without scales are usually said to be naked. A few fishes have lost their scales entirely. Scales are of several types. Several of the most primitive bony fishes possess hard rhomboid or diamond shape scales which do not overlap and are called ganoid scales (Fig. 6). Many primitive fishes also have heavy bony plates on the body covering the heads. In the teleost fishes the bony plates of the head have been incorporated with the internal skeleton and are not easily discernable.

... which are really modifications of the same scale ... other bony fishes. Each scale is a thin shingle of bone with the exposed part covered by a very thin skin. ...le is formed by concentric layers of bone (circuli) which are laid down at the margin of the scale as the fish grows. During the winter when growth ceases or is retarded, the scale may suffer some re-absorption at the margin. When growth is resumed in the spring this causes a distinct mark known as an annulus which is used to determine the age of the fish. Ridges appearing as lines radiate out from the center of the scale and are known as radii. The simple smooth scales are the cycloid type (Fig. 7). Ctenoid scales (Fig. 8) are similar, but are differentiated by tiny spines covering the exposed portion. Frequently the scale must be removed and magnified to determine the structure. Scales are usually restricted or may be absent on the head. In some fishes the scales may be absent from the nape, belly and breast. The scales are counted on various parts of the body for identification (see page 14 for various counts). Some scales are modified as the enlarged scales on the mid-belly of some darters. Many darters and some killifishes have an enlarged humeral scale located just behind the opercle and above the base of the pectoral fin. The thin skin of fishes contains numerous mucous glands which keep the skin covered with a slime which is protective, preventing bacteria and moulds from infecting the delicate skin.

The head of a fish includes the gill region which corresponds to the neck and throat region of higher animals. The fleshy part of the head before the eye and above the mouth is the snout (Fig. 9). Its length is determined as the distance from the front or tip to the anterior margin of the orbit. This part contains the nostrils which are primarily a pair of blind pits and function only as smell organs. Each nostril operture is divided by a flap or fleshy partition into an incurrent and excurrent opening (Fig. 9). The upper jaws under the snout are formed of bones covered by skin and a thin layer of flesh except in a few fishes which develop fleshy lips. The uppper jaw (Fig. 9) consists of several pairs of bones. The front and other pair is the premaxillaries which may be separated from the snout by a distinct groove (See Fig. 200) in which case they are termed protractile. If a bridge of flesh crosses the groove and connects the premaxillaries to the snout (See Fig. 201), they are termed non-protractile. The maxillary (Fig. 9) is on each side of the upper jaw and above and behind, but often parallel to the premaxillary. A splint-like supplementary maxillary may be applied to the upper edge of the maxillary. The posterior end of the maxillary usually marks the end of the jaw, and its position in relation to the eye or orbit is often used in identification.

The lower jaw consists of several bones, the most important consisting of the dentaries which usually bear teeth. In a few primitive fishes, a prominent shield-like bone, the gular plate (Fig. 10), lies between the right and left jaws. The length of the lower jaw varies in different species; in some it may protrude beyond the upper jaw while in others it may be equal or may be shorter or inferior. The forward angle of the mandible [illegible] chin.

Almost any bone in the mouth of fishes is capable of bearing teeth. The roof is formed by an unpaired median vomer on each side of which are palatines extending to the pterygoids. In the floor of the mouth a bump formed by the protrusion of the hyoid bone and frequently bearing teeth, forms the tongue. The mouth when approximately at the anterior end of the head is said to be terminal. If the snout extends considerable before the mouth, the mouth is said to be subterminal.

The barbels are thread-like structures on the head especially around the mouth of many fishes. These are prominent on such fishes as catfishes, but may be small bumps at the end of the maxillary of some minnows (See Fig. 202).

The eye of the fish lies within the orbit (Fig. 9). The external diameter of the orbit or the distance from rim to rim is often uses as a comparative measurement. Behind the eye, the cheek (Fig. 9) is the fleshy area extending to the edge of the preopercle which is marked by a groove. The bony opercle consists of the thinly covered opercular bone below which are the subopercular and interopercular bones. The space under the eye and extending to the maxillary bone is the suborbital region.

The gill or branchiostegal membrane (Fig. 9) is a thin membrane connecting the lower part of the opercle with the throat or with the opposite membrane. The membrane may form a close attachment with the throat or with the opposite membrane (Fig. 11), or it may extend far forward with a wide attachment leaving the anterior extension of the throat exposed as an isthmus (Fig. 12). The gill membrane is supported by a series of small slender bones known as the branchiostegals or branchiostegal rays (Fig. 9).

Under each opercle is the gill or branchial chamber containing usually 4 sets of gills. Each set of gills consist of a pair of bony, flesh-covered pharynegeal arches supporting a double row of finger-like structures (may be filamentous in some) which are the gill rakers and may serve to prevent any objects from entering the gill chambers from the throat. Fishes obtain oxygen from the water which enters through the mouth and passes out over the gills.

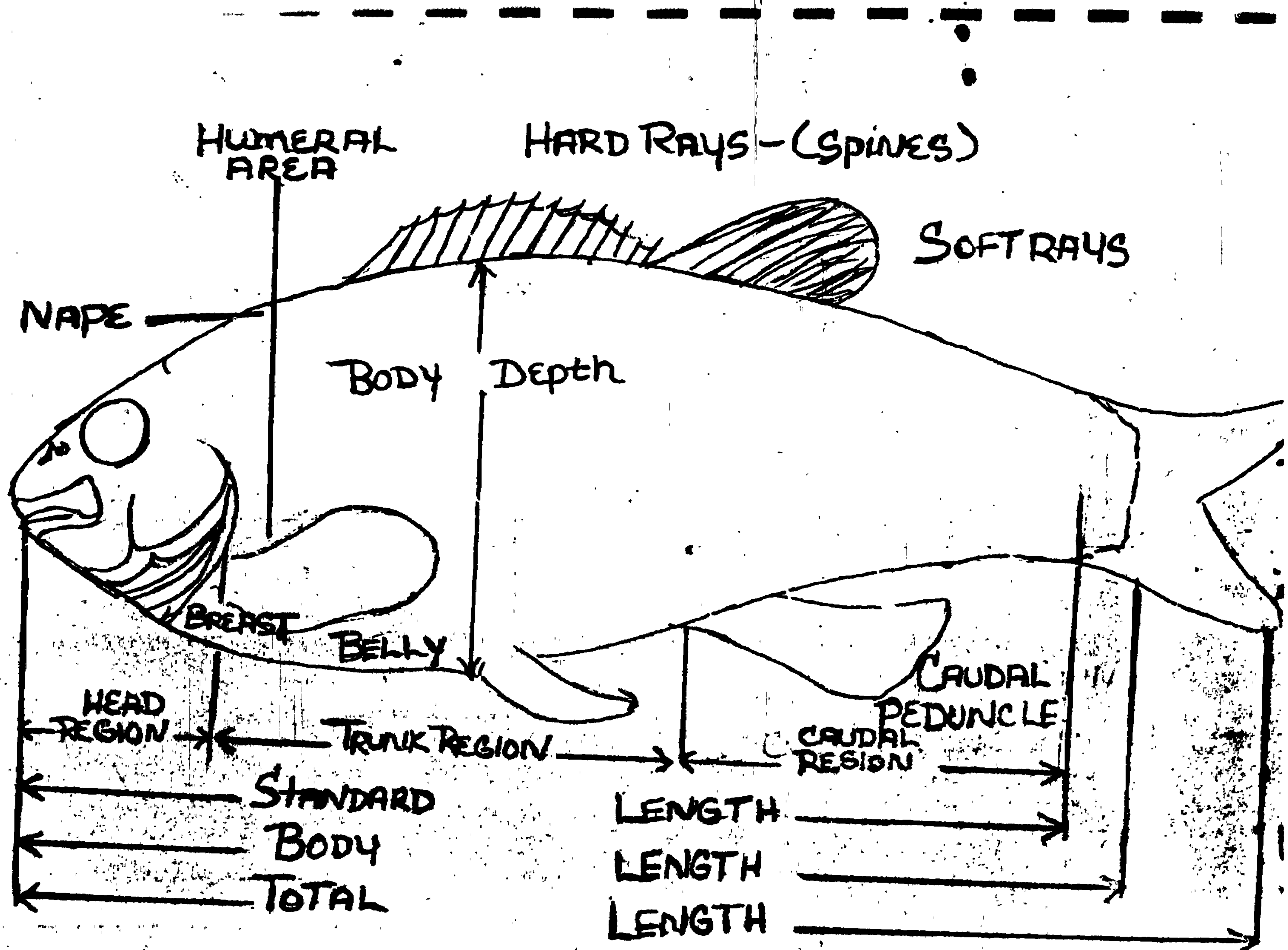
In some fishes a patch of rudimentary gill filaments known as pseudobranchia may appear on the inner surface of the opercular flap, representing a lost front gill. The fifth gill or pharyngeal arches become modifies and no longer bear gills in many fishes, but may develop tooth-like structures known as pharyngeal teeth (See Fig. 32). These are very well-developed in suckers, minnows and other fishes which may not have teeth in their mouths. The arrangement and number of the pharyngeal teeth in the minnows is often an important character used in classification.

Fishes possess an external set of sensory structures known as the lateral line (Fig. 2) commonly seen on the side of the trunk and tail regions. A pattern of pores related to this system can sometimes be traced over the head. The lateral line consists of an external row of pores, one on each scale, one on each scale, which open into a canal imbedded under the skin. The sensory endings of a branch of the 10th cranial nerve lie in this canal. Many functions have been assigned to this system, but the most recent findings indicate that it functions in receiving vibrations from objects thus enabling the fish to swim blindly without hitting objects and also helping in capturing prey.

The size of various structures are important characters used in fish classification. Individual fishes vary so much in size that actual measurements are of little value, consequently, comparative ratios are generally used. Hence, the number of times the eye goes into the length of the snout or the number of times the body depth or the length of the head goes into the standard length is more significant than the actual measurement. Depth of body (Fig. 1) is the greates depth of body measured in a straight line from dorsal to ventral surface at right angles to the length.

The length of a fish is often considered as a straight line measurement from the tip of the jaws or the tip of the snout, if the snout extends beyond the mouth to various posterior parts. Dividers should be used for all small fishes. Total length (Fig. 1) is the distance to the extreme tip of the caudal fin. Fork length is the distance to the fork of the caudal fin. Body length (Fig. 1) is to the base of the caudal fin. Standard length (Fig. 1) is the distance to the last vertebra which can be determined as approximately the flexure line or crease caused by bending the caudal fin. This is the measurement usually referred to in this book.

The number of scales on various parts of the body are useful aids in classification. The number is seldom constant but usually fluctuates within a definit range. The number of scales in the lateral line (Fig. 2) is an important measurement. Careful counting, often under magnification, is necessary. The pored scales can be counted to the end of the caudal vertebrae which can be determined as for the standard length. These counts usually vary within certain limits for each species. When the lateral line is incomplete or undeveloped, the number of vertical scale rows are commonly substituted. The number of scales in a row between the lateral line and the anterior base of the dorsal fin is designated as the scales above the lateral line (Fig. 2). Counts of the scales in a row from the lateral line to front of base of anal fin is known as the scales below the lateral line (Fig. 2). The number of mid-dorsal scales anterior to the dorsal fin, and the number of scale rows before the dorsal fin are frequently used in the identification of some species.



HUMERAL AREA
HARD RAYS-(SPINES)
SOFT RAYS
NAPE
BODY DEPTH
BREAST
BELLY
CAUDAL PEDUNCLE
HEAD REGION
TRUNK REGION
CAUDAL REGION
STANDARD LENGTH
BODY LENGTH
TOTAL LENGTH

Figure 1

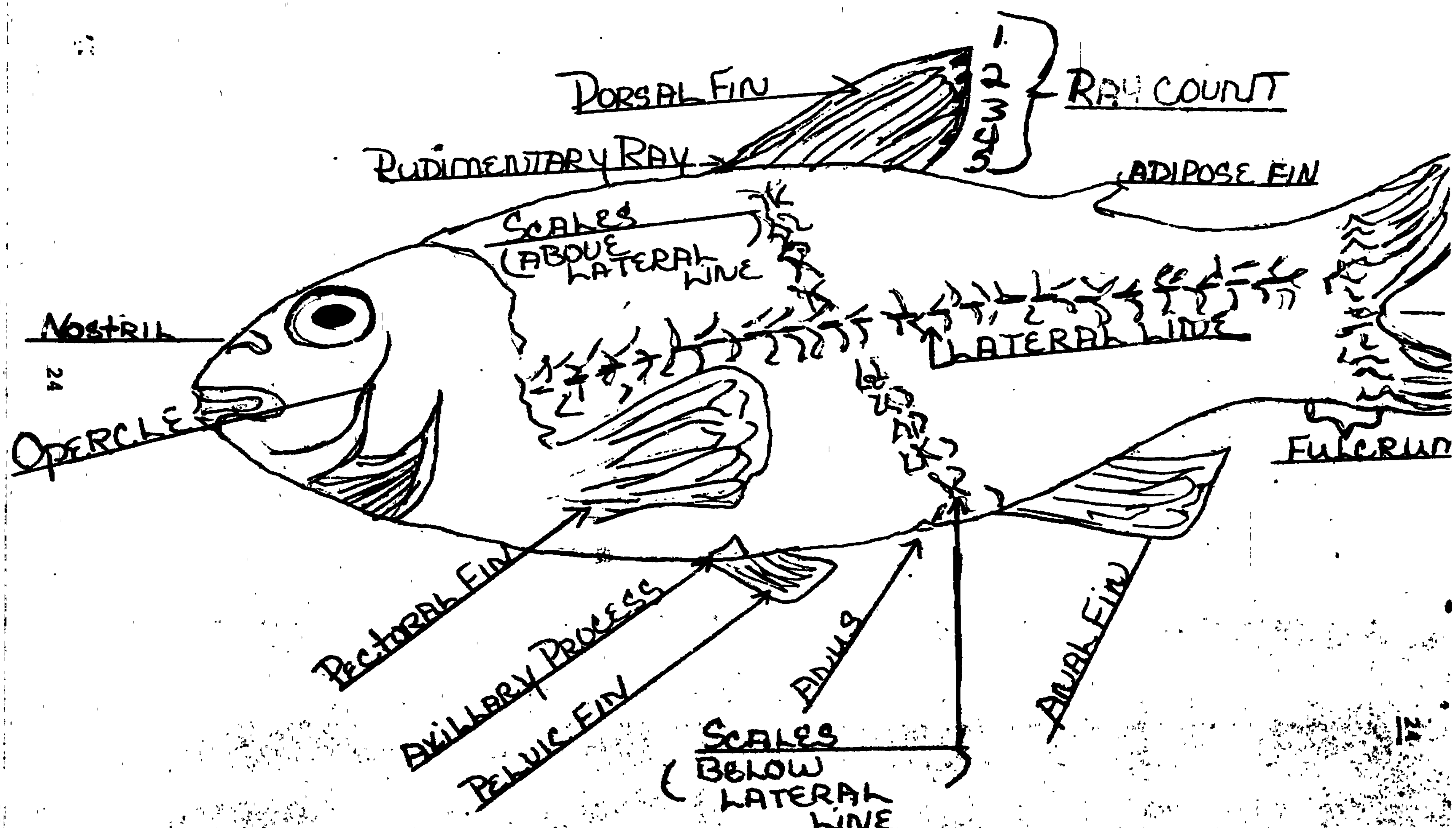

DORSAL FIN
RAY COUNT
1
2
3
4
5
RUDIMENTARY RAY
ADIPOSE FIN
SCALES (ABOVE LATERAL LINE
LATERAL LINE
NOSTRIL
OPERCLE
FULCRUM
PECTORAL FIN
AXILLARY PROCESS
PELVIC FIN
ANUS
ANAL FIN
SCALES (BELOW LATERAL LINE

FIGURE 2

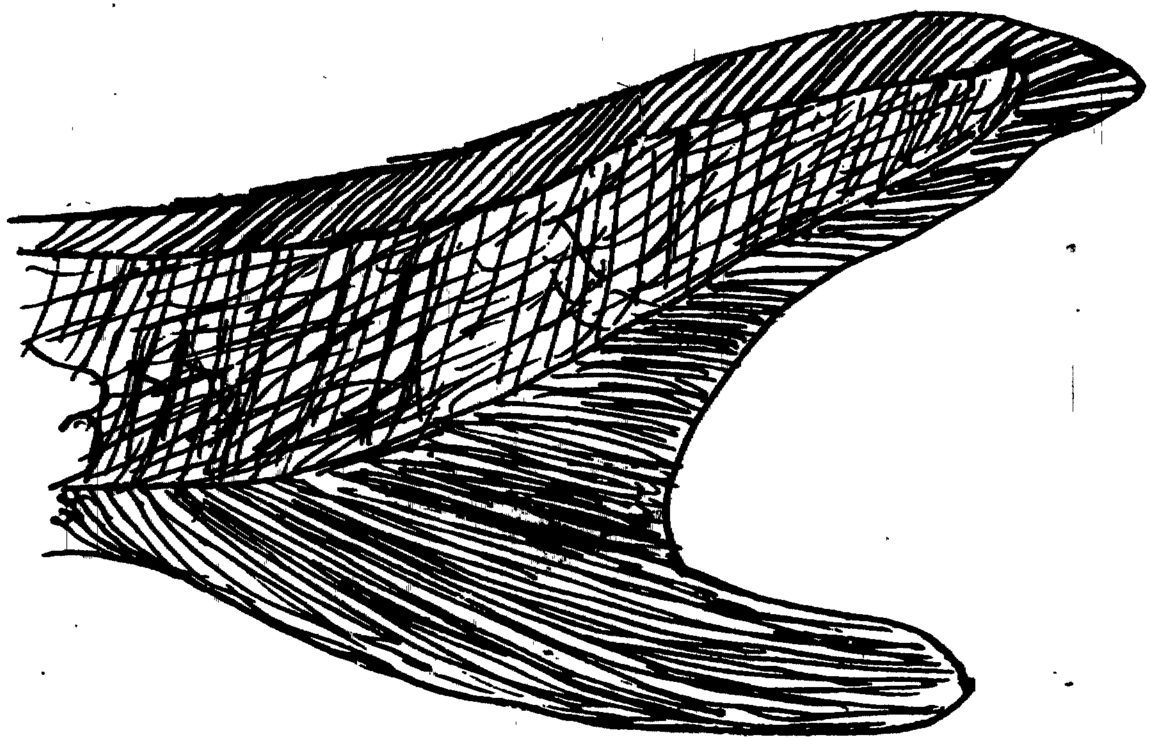


FIGURE 3

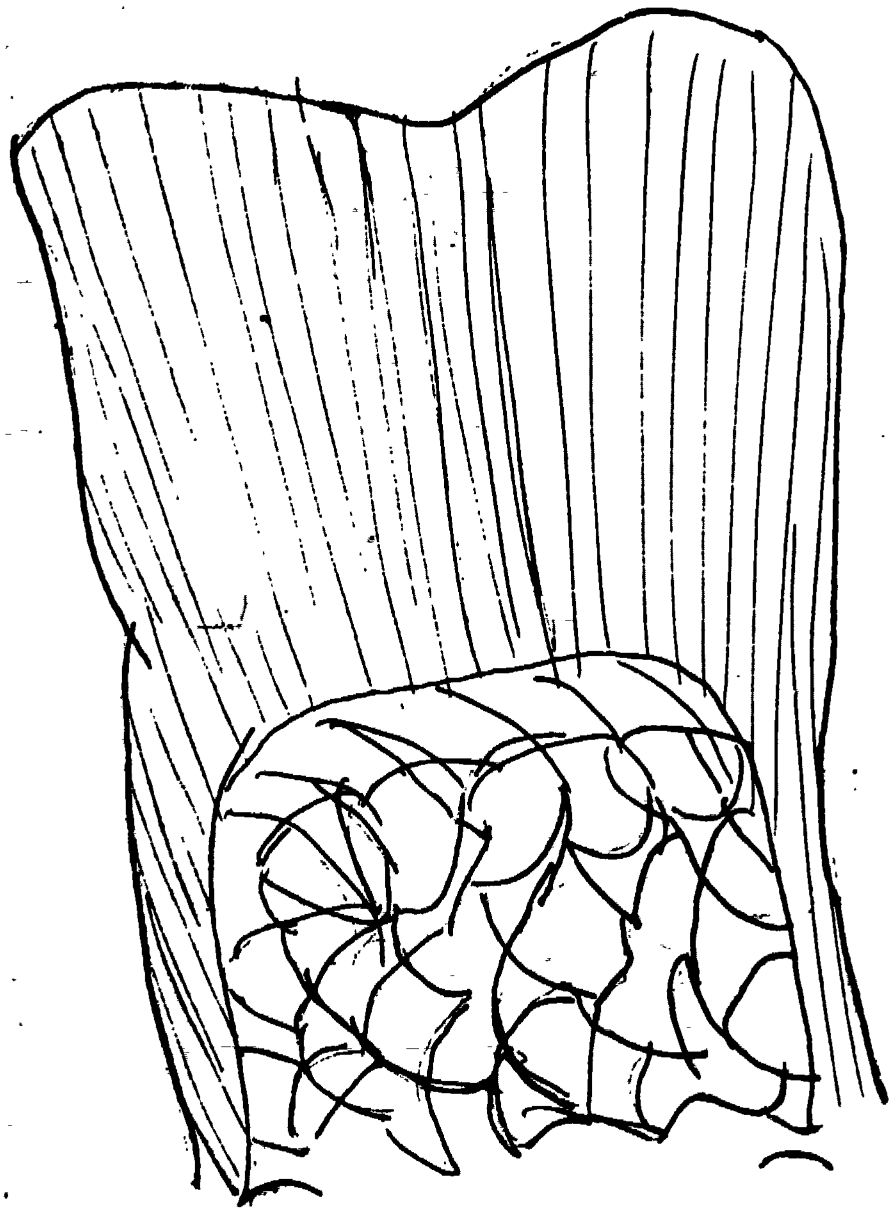


FIGURE 4

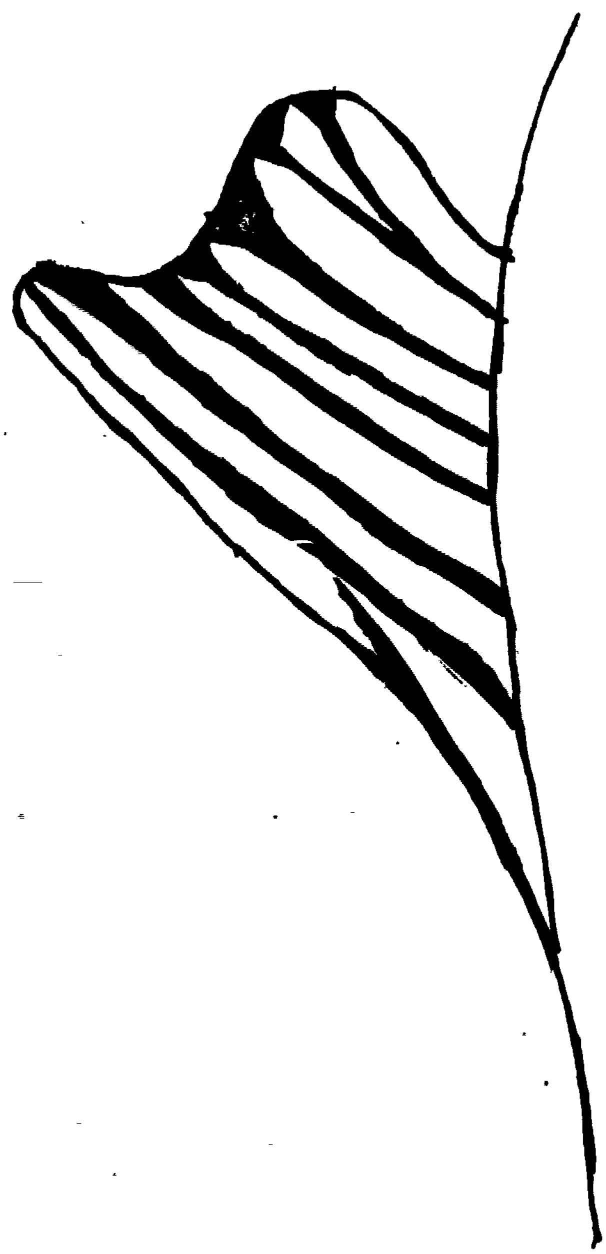


FIGURE 5

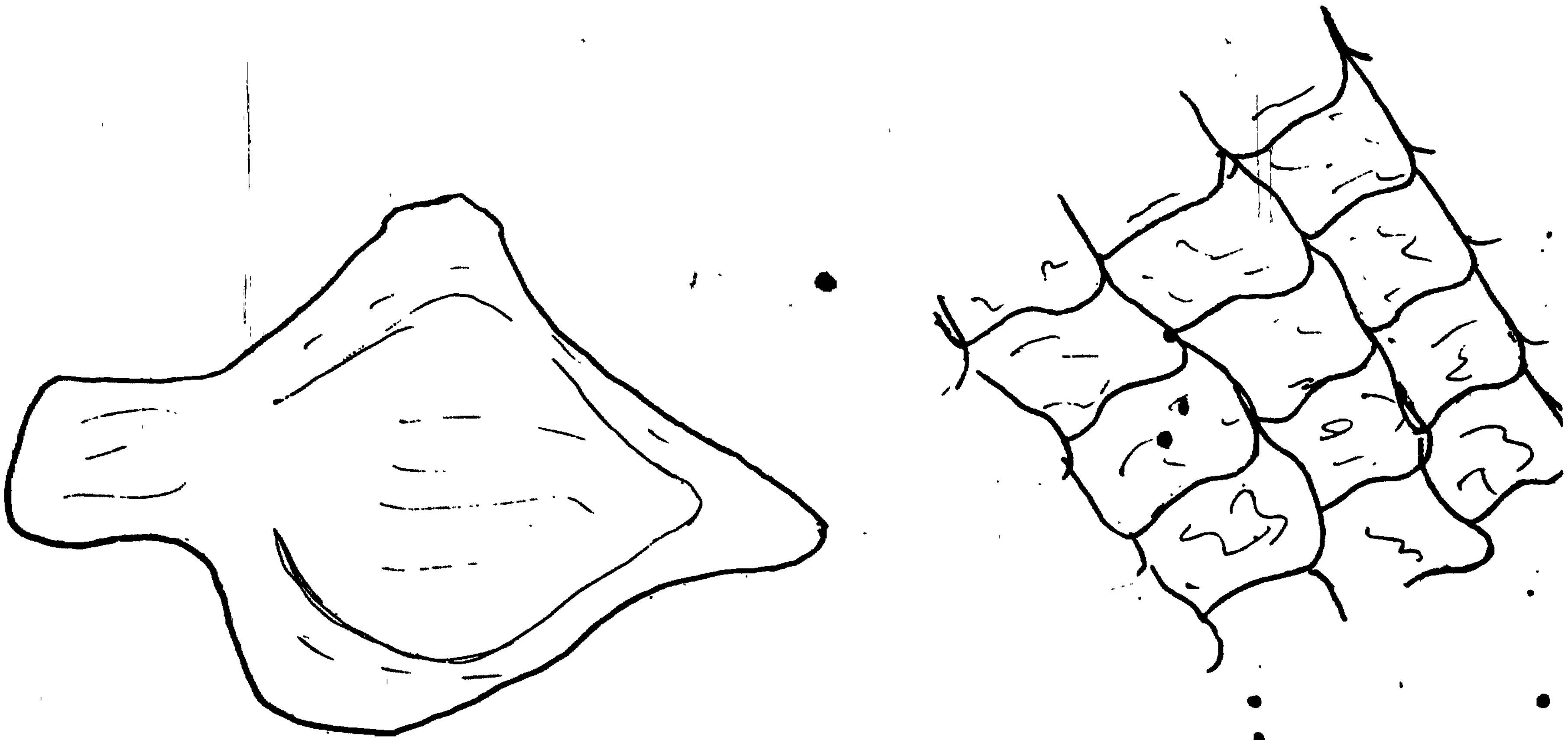


FIGURE 6

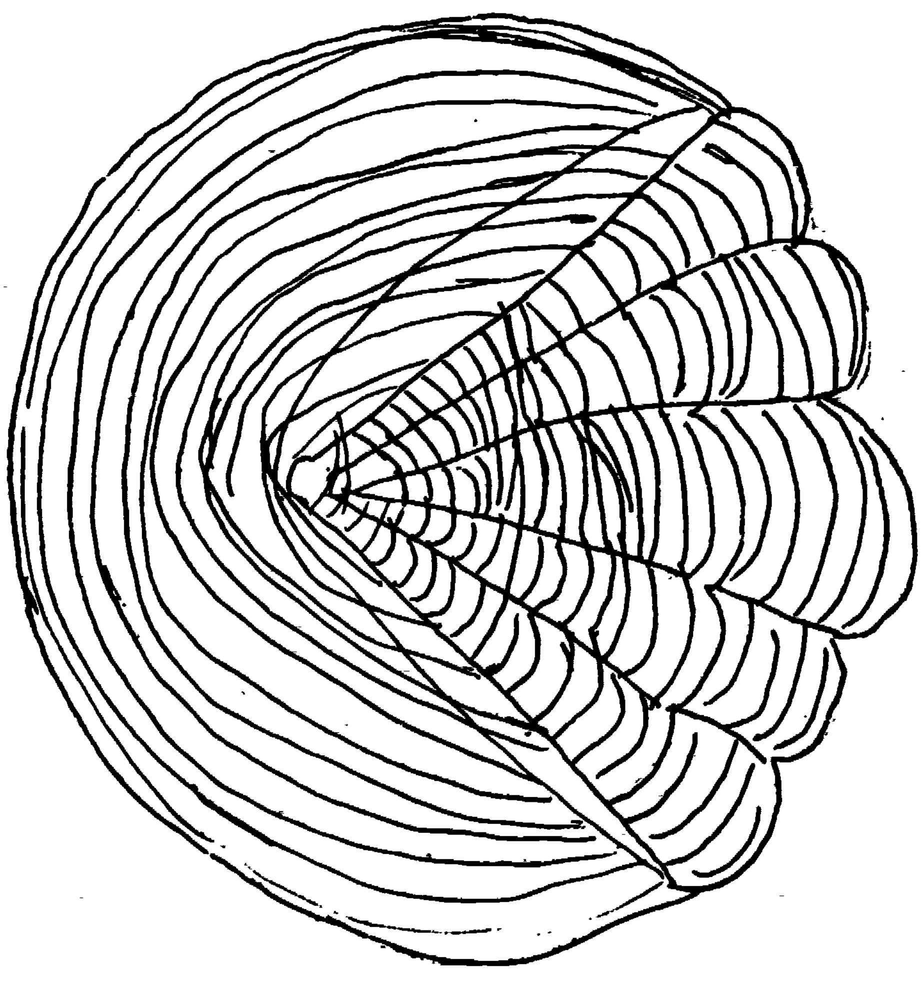


Figure 7

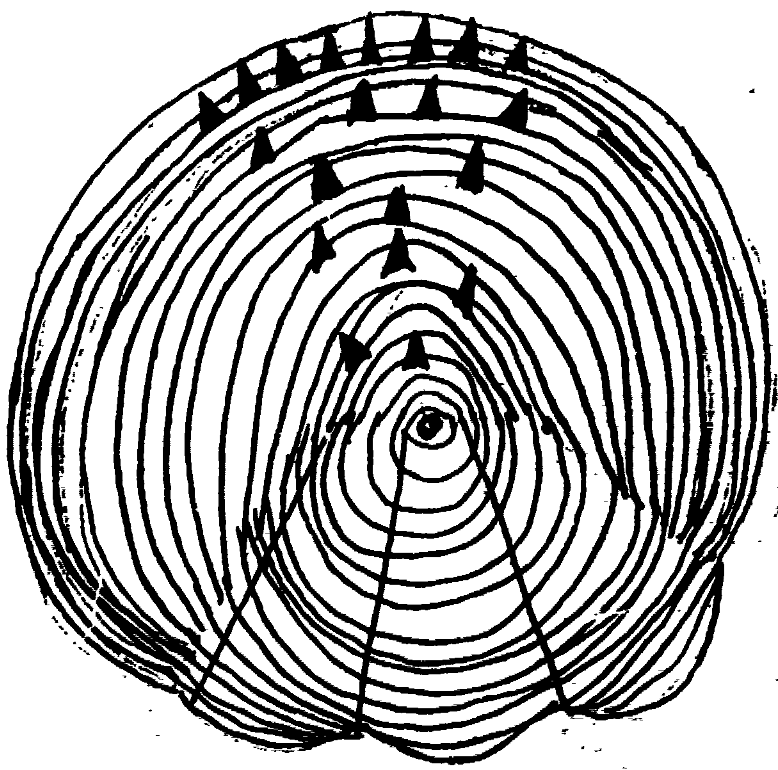


Figure 8

FIGURE 8

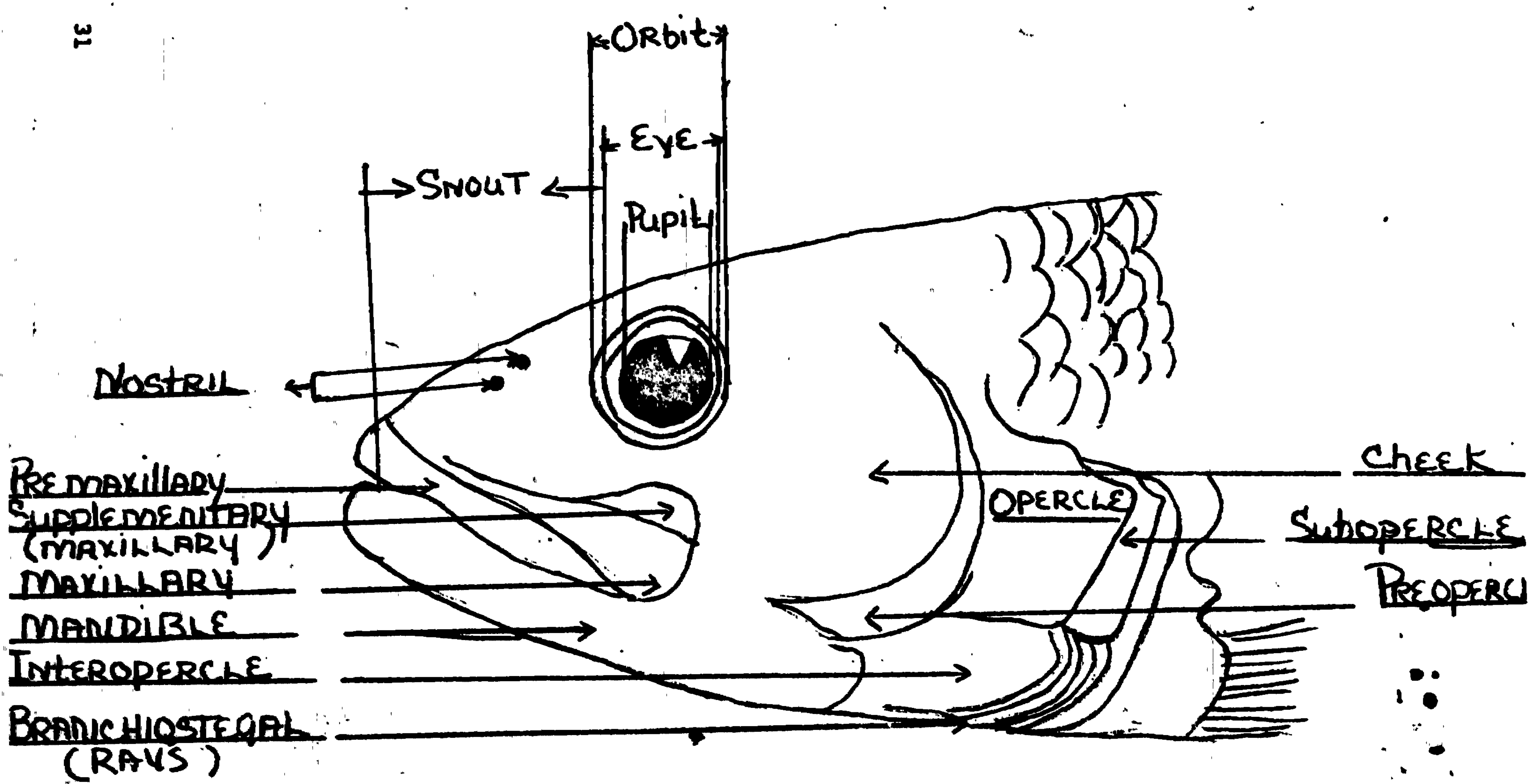

Orbit
Eye
Pupil
Snout
Nostril
Premaxillary
Supplementary (Maxillary)
Maxillary
Mandible
Interopercle
Branchiostegal (Rays)
Cheek
Opercle
Subopercle
Preoperc

Figure 9

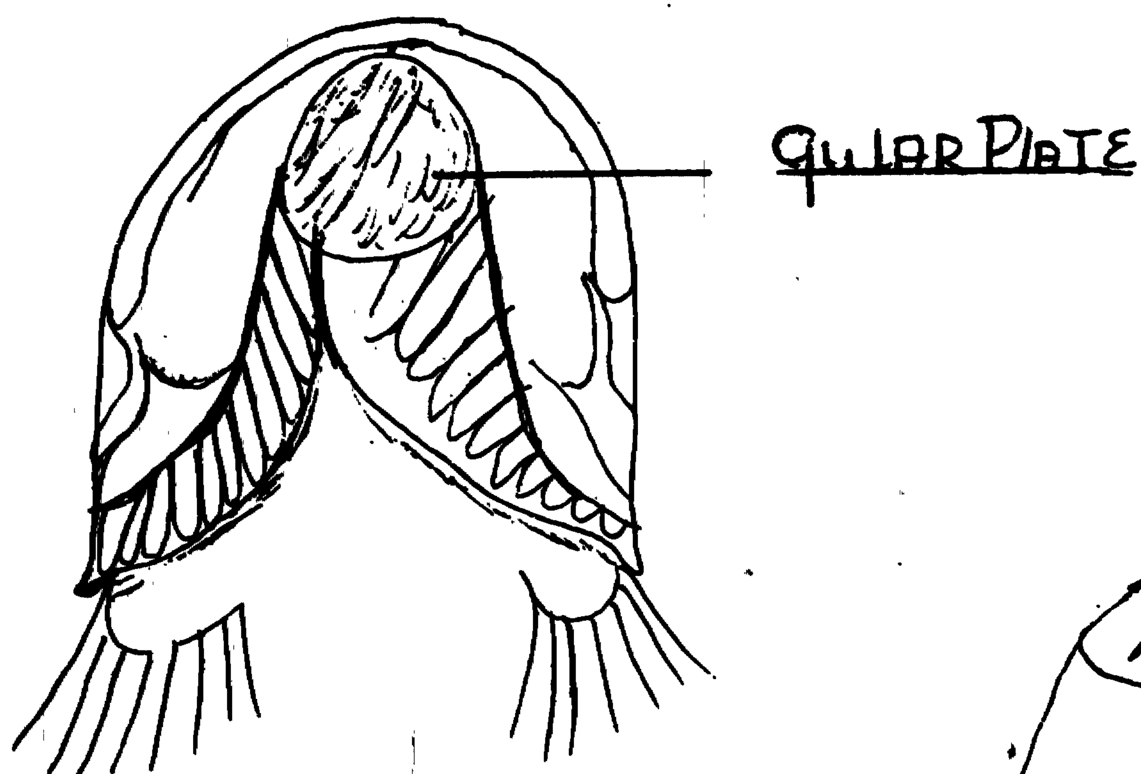


FIGURE 10

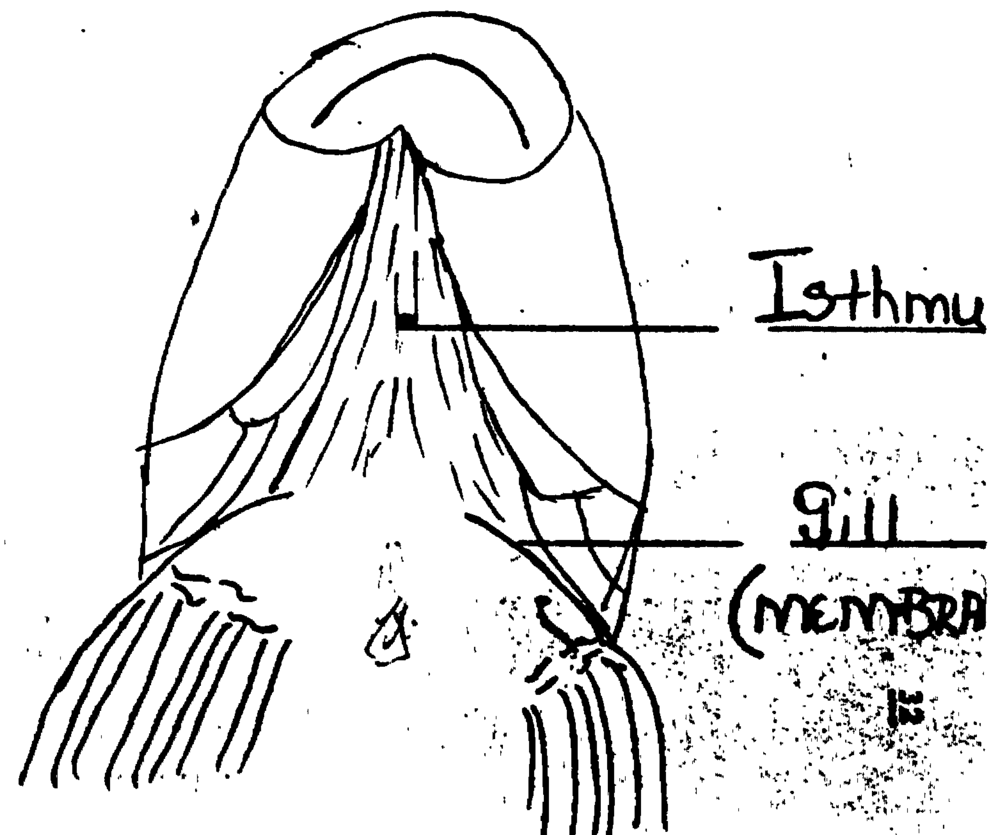


FIGURE 11

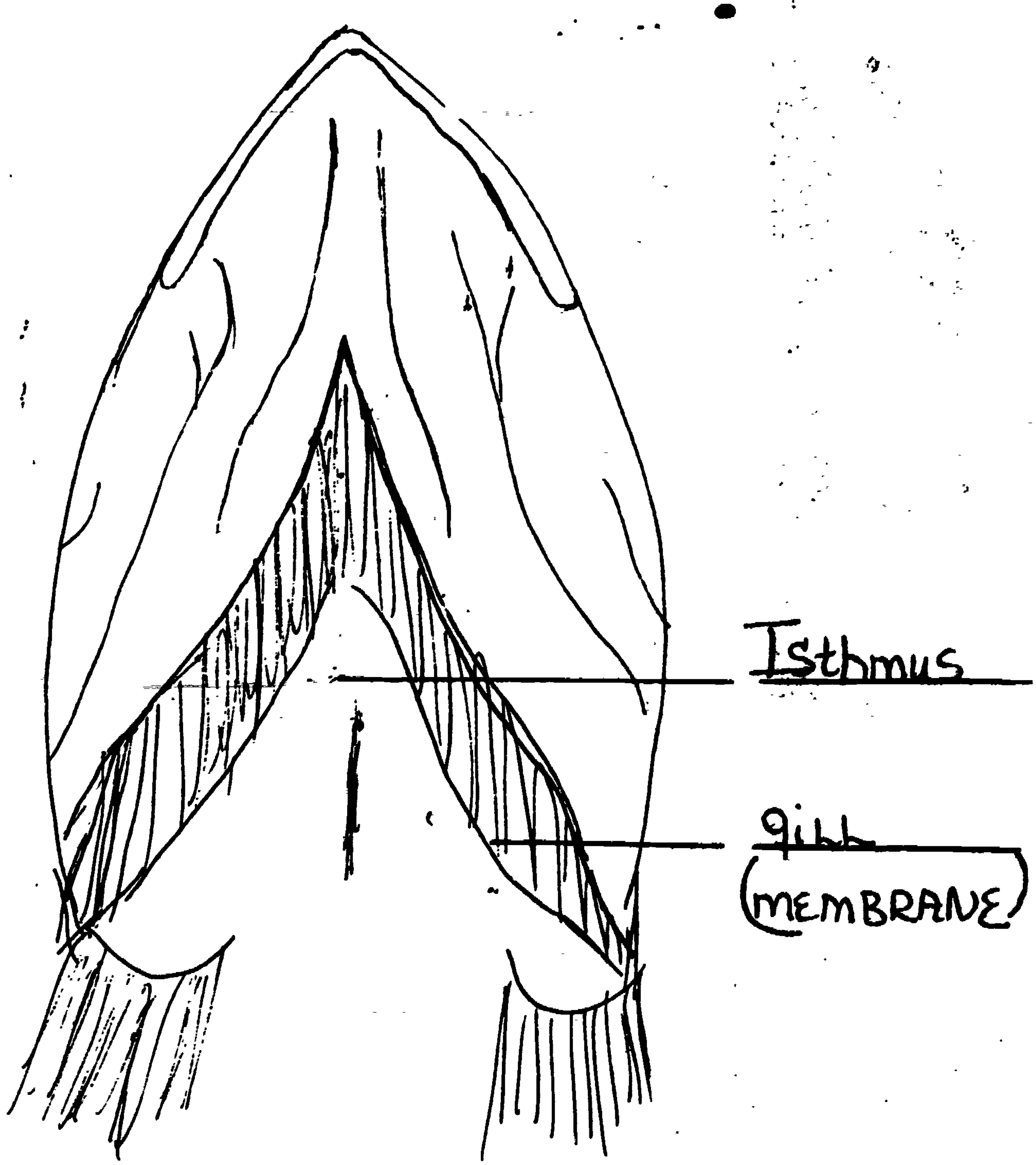


FIGURE 12